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COVER — A reconstruction of the terrain at the Port Kennedy, Pennsylvania, sinkhole that preserved a Late Irvingtonian fauna and flora. (See the paper by Daeschler, Spamer, and Parris in this volume.) Rendered by Bruce Mohn, Copyright © Bruce Mohn.

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An Associated Tiger Shark Dentition From the Miocene of Maryland

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ABSTRACT — An associated partial dentition of the Miocene tiger shark *Galeocerdo* cf. *aduncus* is reported from the Miocene of southern Maryland. The single specimen consists of six teeth, one of which is abnormal, and two broken partial roots. The teeth belong to two adjacent tooth rows and are preserved in situ on a section of the right meckelian cartilage (lower jaw). The abnormal tooth is positioned between the two normally developed rows. This is the first record of associated teeth from a fossil tiger shark, and the first fossil carcharhinid specimen with teeth preserved in situ on the jaw.

Introduction

The Cenozoic record of fossil sharks is based almost entirely on isolated teeth (Cappetta, 1987, and references therein). The tiger sharks, genus *Galeocerdo* (Carcharhiniformes, Carcharhinidae), have a fossil record extending back at least as far as the Eocene of Africa and North America (Applegate, 1978; Cappetta, 1987). Fossil species of this genus have been erected on the basis of isolated teeth, or defined by artificial tooth sets (e.g., *Galeocerdo rosaliensis*, Applegate, 1978). This paper reports on a recently recovered associated dentition of *Galeocerdo* cf. *aduncus* from the Miocene of southern Maryland. The specimen is unusual in that it consists of two partial tooth rows preserved in situ on a section of the right meckelian cartilage (lower jaw).

The Recent tiger shark (*Galeocerdo cuvier*) is circumglobal in the world's oceans at temperate and tropical latitudes, and is considered among the more dangerous sharks because of its aggresive and inquisitive nature and its wide range of prey items, including humans (Compagno, 1984). *G. cuvier* reaches a reputed but unconfirmed length of 9.1 m, but most are considerably smaller (3 to 4.3 m) and reports of sharks larger than 7.4 m are unsubstantiated (Compagno, 1984).

Systematic Paleontology

Class: Chondrichthyes
Subclass: Elasmobranchii
Cohort: Euselachii
Subcohort: Neoselachii
Superorder: Galeomorphii
Order: Carcharhiniformes
Family: Carcharhinidae
Genus: *Galeocerdo*
Galeocerdo cf. *aduncus*

Referred Specimen: Calvert Marine Museum Vertebrate Paleontology collection CMM-V-21 (Fig. 1), a portion of the right meckelian cartilage with two partial tooth rows in place.

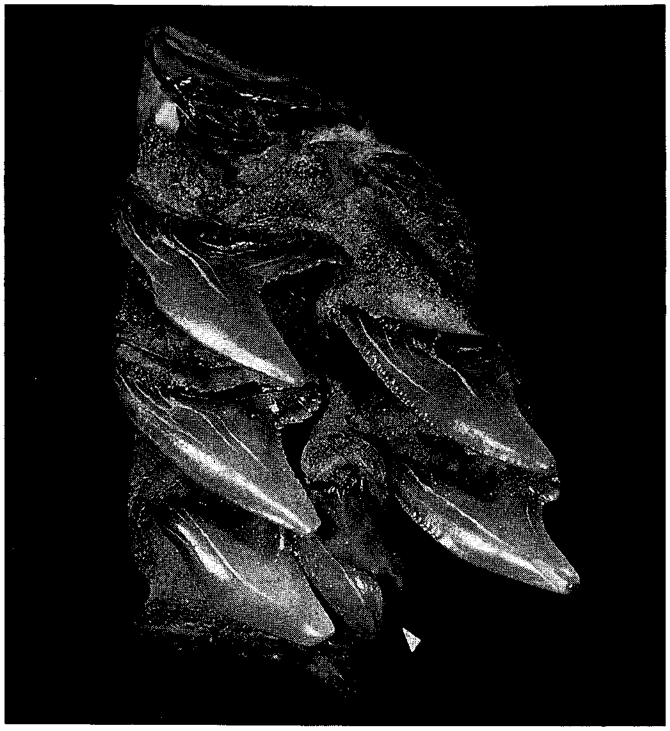

Figure 1. Associated teeth and partial right meckelian cartilage, in lingual view, of *Galeocerdo* cf. *aduncus* (CMM-V-21), from the Miocene Chesapeake Group of Calvert County, southern Maryland. Anterior to the left, ventral to the bottom. Arrow indicates abnormally erupted tooth. X 2.3.

Locality and Geologic Setting

The specimen was collected ca. 1986 by Mr. Ronald Ross, of Arlington, Virginia, on the beach near the northern end of Scientists Cliffs, Calvert County, Maryland (latitude 38°31’40’’N, longitude 76°31’00’’W). This locality (Fig. 2) is on the western shore of Chesapeake Bay along the well-known Calvert Cliffs section through the Miocene portion of the Chesapeake Group. A precise stratigraphic assignment is not possible as the specimen was found as beach float rather than in situ. The specimen is probably from either the Choptank Formation (upper middle Miocene) or the underlying Calvert Formation (lower to middle Miocene), both of which outcrop in the cliffs immediately above the beach where the specimen was recovered. Miocene-age *Galeocerdo* teeth are found regularly along this stretch of beach.

The Miocene deposits in the Chesapeake Bay region formed in an inner shelf marine setting, associated with the Salisbury Embayment which was a major Miocene depocenter

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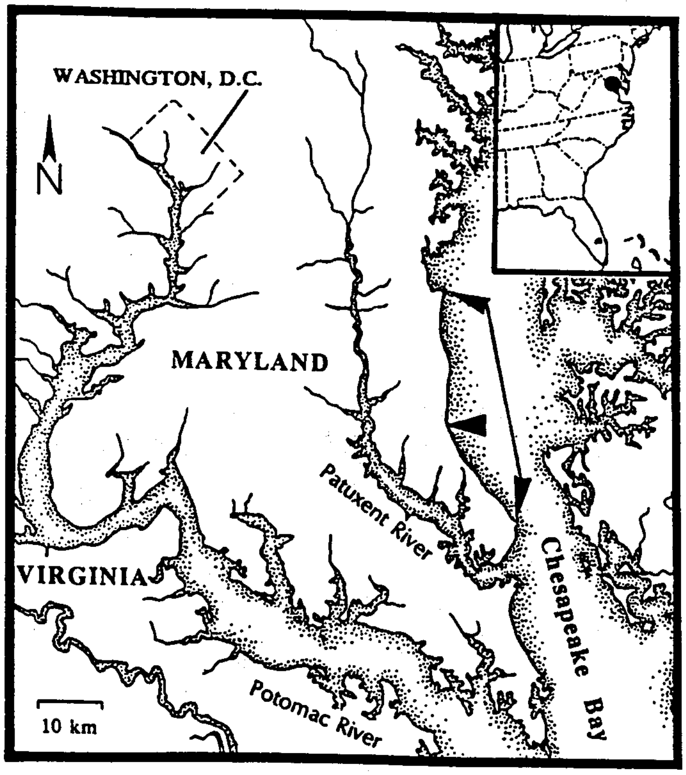

Figure 2. Southern Maryland region and western shore of Chesapeake Bay. Single arrow indicates Scientists Cliffs, Calvert County, Maryland, where the associated *Galeocerdo* cf. *aduncus* dentition (CMM-V-21) was collected. Connected arrows show north-to-south extent of the Calvert Cliffs exposures through the Miocene portion of the Chesapeake Group.

in the western North Atlantic. The regional Miocene fauna includes abundant isolated sharks teeth and marine invertebrates (particularly pelecypods and gastropods); relatively common marine mammals, bony fishes, sea turtles, and a marine crocodile; and occasional seabird and land mammal remains. Recent summaries of the geology and stratigraphy of the Miocene portion of the Chesapeake Group are provided by Vogt and Eshelman (1987) and Ward (1992).

Description and Discussion

CMM-V-21 (Fig. 1) is a section of the right lower jaw, or meckelian cartilage. Two partial tooth rows are represented—there presumably would have been 10 or 11 tooth rows on the right lower jaw if Applegate's (1978) artificial tooth set for *Galeocerdo aduncus* is accurate. The cartilage as preserved is light brown to tan in color, with a slightly granular and pitted surface texture, and is convexly curved on the tooth-bearing (lingual) surface. The cartilage on the lingual surface bears raised ridges that curve around and embrace the bases of the roots of the teeth. The non-tooth-bearing surface of the cartilage has three shallow parallel furrows that run under the roots of the teeth. These furrows have small elongate oval openings directly under the midpoint of each of the roots, indicating the position of the nutrient grooves that lead onto the lingual side of the roots.

The enamel on the teeth is glossy and well-preserved, but the margins of the teeth and the serrations are worn, probably from being in the water. The teeth are strongly notched along their posterior margins, with the pointed cusps reflected posteriorly. Each cusp tapers to a narrow pointed apex. The relatively narrow apices suggest that these are lower teeth, while the strong posterior bend and relative size of the cusps indicates that the teeth are anteriors or laterals, rather than symphyseal or medial teeth (which have more erect cusps and are nearly symmetrical), or posteriors (which have relatively smaller and much flatter crowns). The two most complete teeth have strongly developed serrations on the enamel shoulder just below the notch, as is typical for *Galeocerdo*. The more weakly developed serrations along the unnotched anterior margins of the teeth are poorly represented, again almost certainly owing to postmortem water wear. This is further supported by the fact that the teeth are folded back along the inside surface of the lower jaw, indicating that they are replacement teeth and could not have been worn as a result of being a functional part of the dentition before the shark died.

The abnormal tooth is located near the ventral margin of the preserved piece of cartilage and between the two normal tooth rows. It consists of one central rounded cusp with asymmetrical ridges of enamel on either side, and is twisted approximately 90 degrees out of alignment with the other teeth. Narrow furrows separate the central cusp from the adjacent ridges of enamel, suggesting the possibility that this abnormal structure originated from more than one tooth germ. In overall aspect this unusual tooth bears a superficial resemblance to a mammalian premolar or molar. Abnormally developed dentitions in sharks have been reported as the result of injuries to the jaw cartilage and/or gum tissue and are typically symmetrical (Gudger, 1937; Cadenat, 1962), but the abnormal tooth described here is not accompanied by obvious damage to the immediately surrounding cartilage and is asymmetrical.

The normal teeth on CMM-V-21 closely conform to those that have been assigned to *G. aduncus* by Applegate (1978), and differ from those of the Recent species *G. cuvier* in having noticeably narrower crowns and apices, flatter anterior margins, and relatively smaller size. Unfortunately, because only lower teeth are represented, the specimen discussed here does not resolve the question of whether *G. aduncus* and *G. contortus* (the other Miocene tiger shark species thought to occur in eastern North America) are in fact different species, or whether teeth assigned to the two forms actually belong to a single heterodont species. Purdy et al. (in prep.) maintain that *G. aduncus* and *G. contortus* can be distinguished as separate forms, while Applegate (1978) believes in a single species properly referred to as *G. aduncus*. Another possibility is that the two tooth forms pertain to one sexually dimorphic species. This question can only be unambiguously resolved by finding associated Miocene *Galeocerdo* dentitions that include both lower and upper teeth, and then applying more rigorous criteria for delineating species such as the multivariate statistical approach advocated by Naylor and Maisey (1990).

There are at least two other published Cenozoic records of associated fossil shark teeth preserved in natural association and/or in place on jaw cartilage. Woodward (1899) figured an odontaspid specimen from the Eocene London Clay Formation of Kent, England, which consists of 14 total teeth and the symphyseal region of the left lower jaw, preserved inside a phosphate nodule. Ward (1988) recently redescribed this material and assigned the specimen to *Carcharias hopei*. Uyeno et al. (1990) discussed an associated dentition of the lamnid *Isurus hastalis* from the Pliocene of Japan that numbers fifty teeth, including a file of six naturally arranged teeth from a single tooth family of the left lower jaw.

The scarcity of records of Cenozoic shark specimens with teeth and jaw cartilage preserved in association reflects the low preservation potential of cartilage in Cenozoic marine deposits. The *Galeocerdo* cf. *aduncus* specimen described here represents the first report of an associated fossil tiger shark dentition, and is the first such specimen belonging to the large and diverse Family Carcharhinidae.

Associated fossil shark dentitions, whether in museum collections or in the possession of private collectors, should be sought after and recorded. When available they offer the most objective means of resolving taxonomic problems that have arisen from erecting new chondrichthyan taxa on the basis of isolated teeth.

Acknowledgments

The specimen discussed here was collected ca. 1986 and donated to the Calvert Marine Museum in 1990 by Ronald Ross, of Arlington, Virginia, whose generosity is greatly appreciated. The specimen was first brought to my attention by Ms. Sandy Roberts, of Scientists Cliffs, Maryland, whose collecting efforts have made a significant contribution to our knowledge of the Chesapeake Group Miocene. I am particularly grateful to Robert Purdy (Smithsonian Institution) for time spent discussing fossil sharks and for allowing me to examine his research material. Helpful suggestions and information were provided by the following: S. Applegate, G. Hubbell, J. Maisey, P. Rasmussen, L. Sorbini, and J.D. Stewart. Financial support was provided by the Lincoln Dryden Paleontological Fund of the Calvert Marine Museum, and by the Calvert County (Maryland) Board of Commissioners.

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